ERIC Document Resume	See Instruction Sheet	DATE OF RESUME	DATE RECEIVED

A. PUBLICATION DATA

1. ERIC NUMBER	2. ORIGINATOR CONTROL NO(S).	3. IDENTIFICATION NO.	DO NOT WRITE IN SPACE BELOW
ED002335	N.A.	N.A.	

4. AUTHOR(S): N.A.

5. TITLE OF DOCUMENT ABSTRACTED: Nova Science Unit 1. Measurement

6. PUBLICATION TITLE: N.A.

7. EDITOR(S): N.A.

8. PLACE OF ORIGIN
ORG. Nova High School
ST. Fort Lauderdale,
CITY, STATE Florida
TELE. EXT.
INST/LOC CODE

9. PUBLISHER OR SOURCE
Nova High School
Fort Lauderdale, Florida

10. VOL.	11. PAGES	12. MO./YR.	13. TOTAL PP.
N.A.	N.A.	N.A.	21

MICROFILM COPY AVAILABLE YES [X] NO [ ]

COPYRIGHT GRANTED YES [ ] NO [X]

COPYRIGHT RELEASE FILED YES [ ] NO [ ]

TYPE OF REPORT
PROPOSAL [ ]
IN-PROGRESS [ ]
FINAL [X]
FOLLOW-UP [ ]

OTHER ERIC REFERENCES:

ERIC SATELLITE CODE

B. INDEXING DATA

14. SUBJECT AREA

15. TYPE OF ENDEAVOR Teacher's Guide

16. INDEXING TERMS (6-12)

laboratory experiments	measurement tools	volume	laboratory equipment	
curriculum guide	metric system	mass		
secondary education	science	data sheets		

17. ABSTRACT (MAX. 250 WORDS)

A science unit on measurement is presented. Included are an introduction to the metric system and some tools of measurement. Students are given a homemade system of measurement which utilizes a grain of rice as its basic unit. The students are given experiences with the metric system; through these experiences, the students see the need for standards of measurement. Through laboratory work and experiments, the students learn to use such simple laboratory equipment as the ruler, graduated cylinder, and bunsen burner. Data sheets are used for recording information.

ERIC No.

18. SOURCE OF ABSTRACT

C. FUNDING DATA

19. SUPPORTING ORGANIZATION	20. DIVISION OR DEPT.	21. CONTRACT NO. / PROJECT NO.
	22. TOTAL COST OF PROJECT	
	23. DURATION OF PROJECT	U.S. Department of Health, Education, and Welfare Office of Education

ERIC Form 1

Reid Apr. '64 Lab

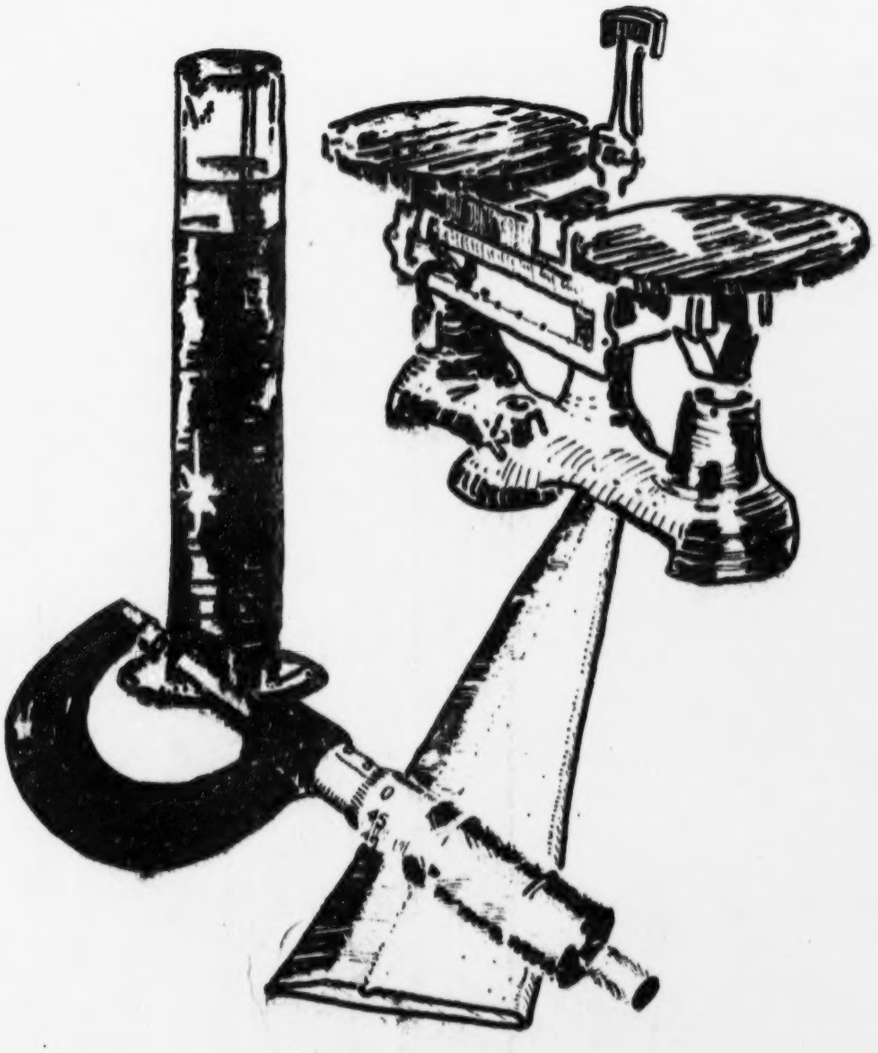
ED002335

NOVA SCIENCE UNIT 1.

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education

This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated do not necessarily represent official Office of Education position or policy.

MEASUREMENT



50695 ED002335

Your science teacher will tell you that this book is a sphere. The book is, as a matter of fact, round. Now you have this fact on good authority. Your science teacher says so, and he is a man of education, a source of light on the darkness of ignorance. Dare you question this authority? Suppose you do question this authority. How do you do it? Certainly you don't jump up in the middle of the class and dispute this. You would probably start out with a rather weak "Are you sure?" You might step after class and express disbelief. Have you stopped to think that you might be wrong? Have you really looked at your book? What evidence do you have that it is not a sphere?

Well, a sphere was pretty well defined by Miss_____, and nobody has said that she was wrong, so she must be right. If she is right, Mr._____ is wrong. Majority rules. Besides, the book looks like a sort of rectangular solid as defined by Mrs._____ several years ago. Let's take a vote in class. We can also ask people on the street.

So far we have done nothing scientific. In science, one right is a majority. Let's investigate the book with instruments and with a critical eye and base our judgment on evidence, not hearsay. See what you can do about this and report your findings.

Have you been this critical of other statements? You have been told that the earth is round--(or an oblate spheroid--what is that?)--but have you tried to find out for yourself? How many tales have you believed because they were accepted? Write out your evidence that the earth is not flat. Compare this with your evidence that it is flat. Use your common sense. Actually, it is hard to believe that the earth is round and investigation of the shape of the earth before airplanes, rockets and other modern inventions was pretty difficult for ordinary people. The classic stated evidence was a ship disappearing on the horizon. Have you really considered this?

Let us go back in time to the Greeks (or Romans, if you prefer). The ships were small, the sails small, and the horizon was far away. (How far away is it?) Telescopes hadn't been invented yet. How could you tell if the sail disappeared from the bottom first or not? Yet by this time, men said the earth was round and had calculated its diameter properly.

In the time of Columbus, ships had grown to 90 feet in length. Still pretty hard to see on the horizon. Besides, ships in ground swells become invisible or only show the tops of their masts. Hardly a convincing point. Can you believe that Columbus used this to convince people that the world was round? Magellan's cruise went a long way toward proving it to the average man when his ship sailed west around the earth and returned to its starting point. At least it didn't fall off any edges. (What other shapes could the earth have been?)

About 200 B. C., Eratosthenes, already convinced that the earth was round, set about to prove its shape and size. The evidence had been available in the shadow of the earth on the moon during eclipses.

Anyway, he discovered that on a certain day the sun would shine down a well near Syene, Egypt. Syene is about 500 miles south of Alexandria. He found a well Alexandria and discovered that a shadow was cast that indicated that the sun was 7^{0} 12 south of straight up. He did this on the same day that it was shining straight down the well at Syene. Using ratios, he calculated the circumference of the earth to be 25,000 miles. Pretty good work, wouldn't you say? Erathosthenes was a keen observer and quite interested in being scientific. He used every tool and all the information he could find to solve his problem.

We want to help you be able to solve your problems too. In the next month you will learn ways of measuring, comparing, seeing better and recording what you have done so that you won't forget it.

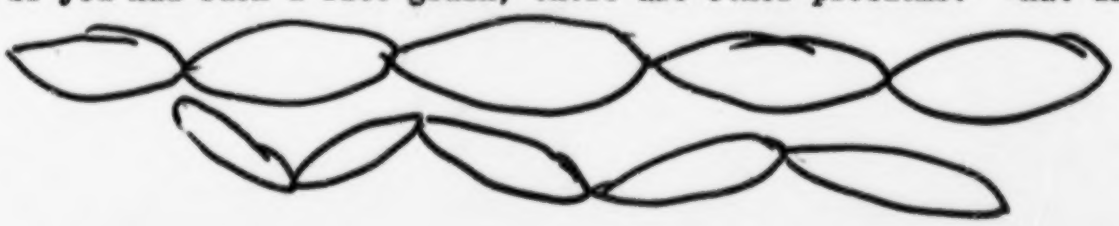
The circumference of the earth was described in the Greek equivalent of miles because we understand this unit of length. Without standards, measurement is vague and not reproducible. Our present standards, the ruler for example, are based on older ideas. You have heard the statement: "As alike as two peas in a pod." If peas are all alike we could describe this page as so many peas long and so many peas wide. Assuming so many peas to a pod, perhaps we could have the paper some length like 7 pods, 3 peas long. In this case, you see each pod is naturally divided into peas. Unfortunately, the peas are not all alike nor are the pods duplicates of each other. There are big peas, little peas, shrunken peas, all kinds of variations. Maybe we can find something better. Try a barleycorn. You never heard of one? Look it up and find our about it as it was once a standard unit of length.

We can approximate this barleycorn with rice. Occasionally a rice grain comes along that looks as if it had been sick or maybe stopped on, but we can weed out these few and proceed from there, laying them end to end like this:

Measure a book or something with your rice, be sure to record your measurements. You can see a sample record of measurement in this folder. Do not be afraid of recording complete information. Trade objects with your neighbor. Keep your rice though, and don't lose any---we may need it later. After you have measured the object given to you by your partner, compare your information with his. If you don't agree, who is right? Have him use your rice. If the results are not good, see if it is just the way he did it or if there is a difference in the rice. Actually, it would take more rice grains to go in a wiggly line than it would if they are laid stright very carefully.

How different is your answer with your rice than his answer with his rice? The difference between your measurement with your rice and his measurement with his rice is a degree of precision of this particular system. If you come out to within one rice grain of each other, you can make an error adjustment for your measurement. If the object is 100 rice grains long and he comes out with 99 rice grains, then the difference or the error is one grain in 100 and you have a pretty fair precision. Perhaps when you get to the end of the object, you discovered that you could put a portion of a rice grain on it, but maybe there wasn't quite room for a whole grain of rice, and you may say that it is 100 $\frac{1}{2}$ rice grains. This is all right as long as you don't try to over-do it. It gets a little ridiculous when you start coming up with ideas like 1/20th of a rice grain or, even worse, 1/100ths of a rice grain, which obviously can't be done since the little rice grain doesn't have any marks on it that ell you that it is 1/100ths of a rice grain. The use of a magnifying glass would help if you had a special little rice grain with division marks on it.* It is almost impossible to get a fine measurement in this fashion.

* Even if you had such a rice grain, there are other problems. What are some of them?



This whole process of measurement can be simplified somewhat by gluing these rice grains in a nice straight line on a board and then you won't have to bother lining them up any more. You can hold the board up against the object for a comparison and have written on the board the number of rice grains up to a certain point. Try it. Now it is beginning to look a little bit more like your old friend the ruler. This is one reason why the ruler was built the way it is. It is convenient to use in most measuring situations. Once you have convinced yourself about what can be done with the rice grains, then the left-over grains can be returned to the teacher's desk and we can prodeed in a more modern fashion.

One of the devices originated about the time of the French Revolution was the metric system. It is used by scientists today. The metric system was devised by a group of scientists, and it is not too surprising that they like to use it.

Rumplestilkin Smith

1. Measurement of length of object number 12

TRIAL NUMBER	Pods	Peas
1	6	3
2	6	2
3	6	8
4	6	3

Average: 6 pods, 4 peas

2. Measurement of width of object number 12

Trial Number	Pods	Peas
1	4	4
2	4	3
3	4	5
4	4	2

Average: 4 pods, $3\frac{1}{2}$ peas

3. Measurement of height of object number 12

Trial Number	Pods	Peas
1	1	8
2	1	8
3	1	7
4	2	0

Most of the home chemistry sets use a candle or an alcohol lamp in order for you to be able to test tubes and do other little experiments that require heat. The temperatures that you can get with a candle and with the alcohol lamp are not as high as we need for the type of things that we need to do in a science classroom. In some instances, the alcohol torch is sufficient for you can sterilize a needle with it or some little endeavor like this. You can't bend glass or warm up some things as hot as they need to get. One of the devices to improve on this heating system was the bunsen burner. Most of the little gas heaters that you will have in chemistry will be called bunsen burners whether that is their name or not. It is a type of apparatus and this is the early form of it. Some of these burners are Kirchoff burners and others are Fisher burners; there are many variations of the bunsen burner. The burner itself is a very useful and simple device. It works very much like a gas range and if you happen to have one of these at home you may be familiar with it. The burner will do a number of things for you. It will heat water, singe eyebrows, and do other things that may be either helpful or harmful.

The burner consists of several parts. You can refer to the drawing and see what these parts are. There is a base, a collar, a gas inlet, the air inlet and the barrel. Draw a picture of a bunsen burner and label these parts. Be sure you understand which part is which, because if you don't know the names of the different parts of the burner, it may be very difficult for us to tell you how to operate one. You see, you can't operate very well by saying that you turn the little "hickiemajigger" and it is quite necessary for us to develop a specific vocabulary for the science equipment and to adhere to it. Then the descriptions

can be made and everyone can do what they are supposed to do. Now is a good time for you to take the burner apart, look at the parts of the burner, identify them with the names you have been given, and put the burner back together as best you can. When lighting the burner, particularly if it is a burner that hasn't been yours, you should turn the air inlet off so that no air can get in. This gives you a flame that is desireable and like the candle flame and you should not have too much difficulty with it. It will be a luminous flame so that you can see it. It isn't a particularly hot flame and the luminous part of the flame is simply the particles that would have burned up had there been enough air. Now, they are not burning, they are just glowing. When you have a luminous flame about two inches high on the burner, begin to open the air inlet a little bit and watch the flame. Do not open the air inlet so much that it jumps away, but if the air and gas are mixed properly it becomes non-luminous. It should be a pale blue color. There will be a little cone of light blue down near the bottom of the flame. This light blue flame is a different kind of a flame than the darker blue flame around the outside. Everybody knows that the closer you get to a stove or the closer you get to a fire, the warmer you get. By the same reasoning, everyone wants to get as close to the burner as they can in order to get the greatest heat. You can make a simple experiment to show where the greatest heat is in this bunsen burner flame.

You have heard about things getting red hot, white hot, orange hot etc. and you can use this method to determine where the greatest heat is in the bunsen burner. Take a piece of iron wire that is long enough so that you can hold one end in the flame and the other end in your fingers without getting burned and begin to probe in the fire with the piece of

vocabulary for the science equipment and to adhere to it. Then the descriptions can be made and everyone can do what they are supposed to do. Now is a good time for you to take the burner apart, look at the parts of the burner, identify them with the names you have been given, and put the burner back together as best you can. When lighting the burner, particularly if it is a burner that hasn't been yours, you should turn the air inlet off so that no air can get in. This gives you a flame that is de-- sireable and like the candle flame and you should not have too much difficulty with it. It will be a luminous flame so that you can see it. It isn't a particularly hot flame and the luminous part of the flame is simply the particles that would have burned up had there been enough air. Now, they are not burning, they are just glowing. When you have a luminous flame about two inches high on the burner, begin to open the air inlet a little bit and watotch the flame. Do not open the air inlet so much that it jumps away, but if the air and gas are mixed properly it becomes non-luminous. It should be a pale blue color. There will be a little cone of light blue down near the bottom of the flame. This light blue flame is a different kind of a flame than the darker blue flame around the outside. Everybody knows that the closer you get to a stove or the closer you get to a fire, the warmer you get. By the same reasoning, everyone wants to get as close to the burner as they can in order to get the greatest heat. You can make a simple experiment to show where the greatest heat is in this bunsen burner flame.

You have heard about things getting red hot, white hot, orangge hot etc. and you can use this method to determine where the greatest heat is in the bunsen burner. Take a piece of iron wire that is long enough so that you can hold one end in the flame and the other end in your fingers without getting burned and begin to probe in the fire with the piece of wire.

The standard unit of length in the metric system is the meter. This is a word that means measure. It also happens to be a little over 39 inches long. There are meter sticks all around the science building so you won't have any trouble seeing what one looks like. The meter is divided into smaller parts called centimeters which means they are 1/100ths of a meter. There are 100 of these little pieces of a meter in a meter. These are smaller than an inch so they make it easier for us to measure smaller objects. The centimeter is divided into still smaller things called millimeters and these are 1 /1000ths of a meter. There are 1000 of these little marks in the meter and 10 of these little divisions in the centimeter. With no trouble at all then, we can measure to 1/10 of a centimeter and come up with fairly good results. Going back to the rice grains you recall we can measure fairly well to within one-half a rice grain because this was the smallest object that we had in the measurement. In this situation, the smallest unit we have is the millimeter and we can measure to within 1/2 of this. This is the smallest division, measuring to within one-half a millimenter gives a measure that is pretty small. As a matter of fact, it is 1/2000ths of an inch.

Measure some objects with the meter stick, write down your answer in centimeters and then in millimeters. How do the numbers change? Measure these in inches and look at the numbers that you have here. Ignore the fact that you are in the habit of using feet and inches, if you can. Figure out which one would be the easiest to use in measuring. It is easier to wrok with centimeters and millimeters, or it is easier to work with inches or 1/16ths of an inch or 1 /32nds of an inch? How many reasons can you give for your choice?

VOLUME

You can get more confused with volume than any of the other simple units. There is such a diversity of units that it is quite difficult to keep them straight. Some examples of volume measurement are:

Teaspoon, cup, quart, gallon

Cubic foot ($foot^3$), cubic centimeter (CM^3),

Liter, milliliter, barrel, and many others.

Students sometimes wonder if there is such a thing as a cubic quart - is there?

In science, we work with a unit of volume that is a little cube, one centimeter on an edge. This is called a cubic centimeter because it is one. Draw a cubic centimeter on a piece of paper. Make sure it is the right size. You will be working with this in the lab, but you will need a good visual picture of it. Unfortunately, a cubic centimeter (CM^3) has another name - the milliliter (ml), 1000 CM^3 gives us a volume called a liter. If it is a cube, what are the measurements of a liter? Try to draw one on paper. The reason for the change in name is usually a change in <u>state</u> of the material being measured. Solids are usually measured in CM^3, but liquids and gases are usually measured in milliliters (ml) or liters (l). Note that liter is pronounced lee-ter. You will only display ignorance if you call it litter or lit-er.

There are many ways that you can get small volumes. Once you are familiar with the CM^3 and the ML, you can reduce volume in a liquid by means of an eye dropper. Later you will make an eye dropper and count the number of drops of a liquid that will make a cubic centimeter.

You can use calibrated tubes called pipettes or burettes, depending on how they are constructed, that will help measure volume. A very important method is dilution. You will get to try most of these in the lab.

If a solid is a regular shape (square, rectangle), it is not difficult to determine its volume. What if it is a strange shape? See what you can find out about this before you get into the lab.

VOLUME - A LAB EXERCISE

A scientist has to watch for significant details while he works. Many times he makes substitutions that will help him. (How did the substitution of mercury for water in the barometer help?) Scientists are always trying to think of better ways to do things.

We are going to work with volume measurement, starting with a few things that we already know and proceeding from there. You will recall that a cubic centimeter is the unit of volume. It is also called a milliliter, How could you contain this volume?

An easy way to do this is to get a block of wood that is a cube one centimeter on an edge and use the block for a mold. You could make a plaster cast (watch out for air bubbles!) or wrap aluminum foil around it (no mess). Once you have the little cup, don't throw away the block - you may need it again for another cup later.

The easiest way to fill up your cup is with an eyedropper - make one. How many drops from your dropper make up a milliliter? How much is one drop? Keep a record of your tries. When you are satisfied with your results, exchange cups with your neighbor and try his. Compare results and try to account for any differences. What do you have to watch for in deciding when the cup is full?

How could you simplify the use of the eyedropper in measurement? How could it be made more accurate?

When you have a feeling of confidence with your dropper-measure see your teacher for a liquid other than water. Keep an accurate record so that you can compare them. A good volume measure will be accurate regardless of the liquid. If yours works with several liquids, chances are it will work with any ordinary liquid.

Unit 1, Day 10

1. Demonstration lecture on volume, use of volume, etc.

OUTCOMES:

1. Ideas about use of volume measurement
2. Metric units of volume
3. Methods of volume measure that are indirect-dilution
4. Direct volume measurement

DEPTH STUDY

1. Student can make known salt solution, dilute it, reclaim salt from portion, weigh for residue.
2. Regular vs. irregular shaped objects and their volume.

UNIT 1, DAY 11 - 12

MASS

No attempt is made at this time to distinguish between weight and mass. The word "weight" is eliminated from the vocabulary. The student is introduced to methods of massing objects, reading the balances, attempting to standardize a measure. Records are kept and comparisons made.

OUTO

1. Students learn the concept of mass measurement.
2. Students gain manual skills with the balance.
3. Students see relationship of mass units to other units of measurement.
4. Students record, compare results, analyze differences.

Depth Study

Difference between weight and mass (?)

idea of density (relation of mass to volume)

Some words of caution:

When students go into the laboratory to mass things, the material on the balances gets bigger and bigger as they pile more and more things on, and the student gets so involved that he isn't really paying much attention to what he is doing. There isn't any real accomplishment in this pile-up and there might be some harm done. The better the balance the more easily it is broken. Most of the balances that are in the laboratory will have the maximum that they can stand marked right on the balance. A balance may be able to stand 1,000 grams. If you put more than 1,000 grams on this balance it will not have the accuracy it had before. You will notice I didn't say it would break, because this type of breaking is not as obvious as a total collapse. You may say, "Well, the balance looks all right to me," but the balance really isn't all right, because inside, where it is very nicely made, you may have bent a little edge which seems pretty insignificant, but will throw off the accuracy of the balance. It will never be the same again.

As some of you may know, it is possible to crack your arm without really getting it bent out of shape, but the arm had to be put in a cast just the same. In one case you might have a broken arm that is visibly broken and in the other case it is broken, but it doesn't really show. That is sort of the way the balance is. However, it is just as useless to us if it isn't accurate as it is if it is broken. One thing that keeps cropping up time and time again is the significance of a half of the smallest scale division that you will have in your balance; your balance will be accurate to one-half of the smallest scale division,

ıst as your volume measure was accurate to within half of the smallest scale division. For the time being, this is the most accuracy we will attempt in our measuring.

You might compare the method of finding mass with the method of finding volume and see if you can decide which one is the most accurate for describing an object. Can you find some real relationship between the method you have used to find mass and the method that you have used to find volume?

LAB - MASS

In the investigation of the gram, we will need our old friend, the cubic centimenter block. Use it to make another aluminum cup. Check the mass of the cup on the balance and record its mass. Now use your dropper to measure out a cubic centimeter of water into the cup. Does it look level full? (If not, why not?) Check its mass now. How can you find the mass of the water in the cup? What is the mass of this water? Have you followed all the methods we used earlier to arrive at your decision?

Set up some apparatus to remove impurities from the tap water. Repeat the experiment and see if the results differ. How do you account for this difference or lack of difference?

So far we have concerned ourselves with objects that were handy to store, easy to lift and see, and fairly easy to measure. What about things that we will study that do not fit into this category? You can think of many, I am sure. Stars, locomotives, bacteria, atoms, fleas, all present problems that you haven't encountered yet. Each one would require a different approach and different apparatus. You will meet most of these objects later in science and learn how they are measured. Right now we are interested in extending your ability to measure small objects.

You will be given a lecture on the construction and care of the microscope and assigned one to practice looking through - investigate a hair, a piece of dirt or whatever you can find to look at. Choose a letter from this page, preferably a vowel, and observe it under the low power of the microscope. Try to draw it the size that it appears through the microscope. Besides your drawing of the enlarged letter, draw it the size it really is. What happened to it? How much wider is it? Higher? Try the next higher magnification. Repeat the drawing.

Is it easier to measure the enlarged drawing or the regular sized letter? If you know that it has been magnified 100 times, what does this mean? What happened to the letter?

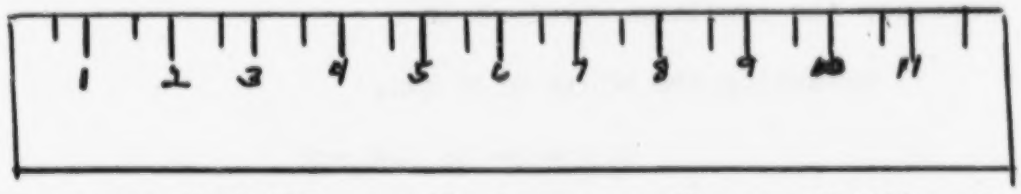
Comment on the accuracy and precision of your measurement. How could these be improved?

Would it be possible to measure the object under the microscope directly? Suggest ways to do this. Try one and compare the accuracy and precision of it with the method you used earlier.

UNIT 1 Day 15

Many of us go fishing and this exposes us to a certain element of the population that stretch the truth. They get carried away with their wild tales of the monstrous fish they have caught. A few of these people have been able to give all fishermen a bad name.

In an effort to combat this contagious habit, fishermen brought out a devise to help eliminate it. This was a special foot ruler.



You can see that this greatly increases the possibility of catching a 3 foot fish (one yard long)* This ruler has been widely accepted by fishermen, and today, when someone says they caught a $2\frac{1}{2}$ foot bass, everyone can believe them.

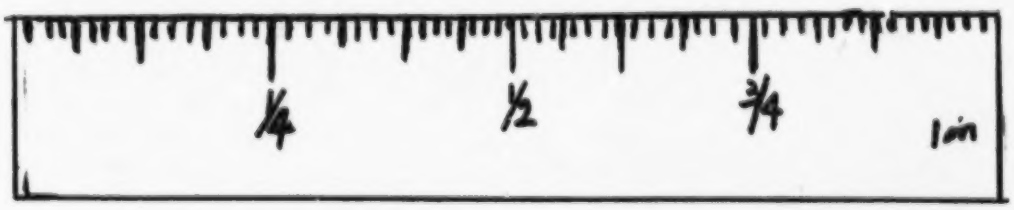
Possibly this doesn't seem right to some of you. You may say "well, that isn't an inch, so twelve of them won't make a foot". It <u>is</u> an inch, though. You cannot argue this. Agreed, it is a mighty inaccurate one, but an inch nevertheless.

Most of us are interested in having an accurate inch, and for good work, our linear measuring tools are checked with a block of metal that has been made very carefully. These are called gauge blocks. We can use these to make sure that our inch is the same as everyone else's inch.

* since one seldom states the mass of the fish, nothing has been done about this.

Fold your paper along the top edge of the ruler. Use this ruler to measure several objects. Can you do it? What is the difference between the readings you get with this ruler and the ruler you are used to using? Why isn't this ruler a satisfactory instrument? Would it ever be a satisfactory instrument? Would it ever be a satisfactory devise? Give conditions for each.

Let us investigate another aspect of measurement. Precision is the measure of reproducibility of measurement - for example: you can get more precision with a micrometer than you can with a yardstick, or, you can get more precision with a yardstick, or you can get more precision with a yardstick than you can by pacing. "Can I keep getting the same answer?" Are the questions asked by one who is only interested in precision. Consider a third inch -



UNIT 1 Day 15

Now we have a little inch, a standard inch, and a big inch. Write down, in tabular form, comments about the relative accuracy and the relative precision of each of these.

On another table, organize information on the accuracy and precision of each instrument you have used so far. Remember - these are based on observation, not wild guesses.

Consider the problems involved in

1) Measuring the width of a hair

2) " " distance to the sun

3) " " " from the surface of the skin to the closest point of the liver in a person (or a mouse, if you prefer)

4) The length of a molecule

5) The distance to a distant star

How do these measurements differ?

How are they alike?

What are common problems in measurement and what are not?
Comment on accuracy and precision in each case.